The WRP Notebook

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Wildlife Habitat Function of Bottomland Hardwood Wetlands, Cache River, Arkansas

PURPOSE: This technical note provides an overview of field research and presents a model for assessing the wildlife community in bottomland hardwoods (BLH).

BACKGROUND: The Wetland Evaluation Technique (WET) (Adamus and others 1987), a technique designed to assess the functions and values of the wetlands in the United States, is currently being used by personnel from the US Army Corps of Engineers, Federal Highway Administration (FHWA), US Environmental Protection Agency (EPA), other federal and state agencies, and the private sector. Under the WRP the WET continues to undergo review and revision. In addition, versions of the WET are being developed for specific wetland types, such as BLH (Adamus, Smith, and Muir in preparation). The research being conducted at the Cache River, Arkansas, is designed to provide the detailed information necessary to develop quantitative models for assessing the biological functions of BLH.

INTRODUCTION: The objective of the wildlife habitat research at the Cache River was to define the relationship between wildlife species composition and environmental features across a topographic gradient. Understanding this relationship contributed to the development of a wildlife community habitat model for BLH. This technical note discusses sampling design, data collection results, and the wildlife habitat community model developed using this information.

The Cache River is located in northeastern Arkansas and originates just north of the Arkansas-Missouri state line. The river flows 203 miles to its confluence with the White River near Clarendon, Arkansas. The river basin is approximately 2,018 square miles in area and is 143 miles long with a maximum width of 18 miles. In the vicinity of the study area the forested floodplain ranges from 1 to 2 miles in width. The main channel of the river has meandered across the floodplain creating numerous cutoffs, side channels, and abandoned channels. Extensive areas of cypress/tupelo backswamp exist along the river. More detailed information about the study site can be found in Clairain and Kleiss (1989).

Wildlife habitat research is being conducted on the floodplain of a fourth-order reach of the Cache River near Gregory, Arkansas (Figure 1). This lower reach of the Cache River supports some of the largest contiguous tracts of BLH remaining in the Lower Mississippi River Valley (Cache River Basin Task Force 1978, US Army Corps of Engineers 1974). Much of the area is publicly owned and is managed jointly by the Arkansas Game and Fish Commission and the US Fish and Wildlife Service.

MAMMAL, REPTILE, AND AMPHIBIAN SAMPLING: Wildlife species composition of the BLH community was determined using 52 sampling arrays installed on transects A and C in May 1988 (Figure 1). Thirty of the arrays included 3 drift fences, 4 pitfall traps, 1 elevated trap platform with a trap set, and 2 ground trap sets consisting of a Sherman live trap and a Museum Special snap trap. Twenty-two of the arrays included all of the above with the exception of pitfalls and drift fences, which could not be installed due to a high water table. Traps were baited with a mixture of horse feed and peanut butter rolled in oatmeal.

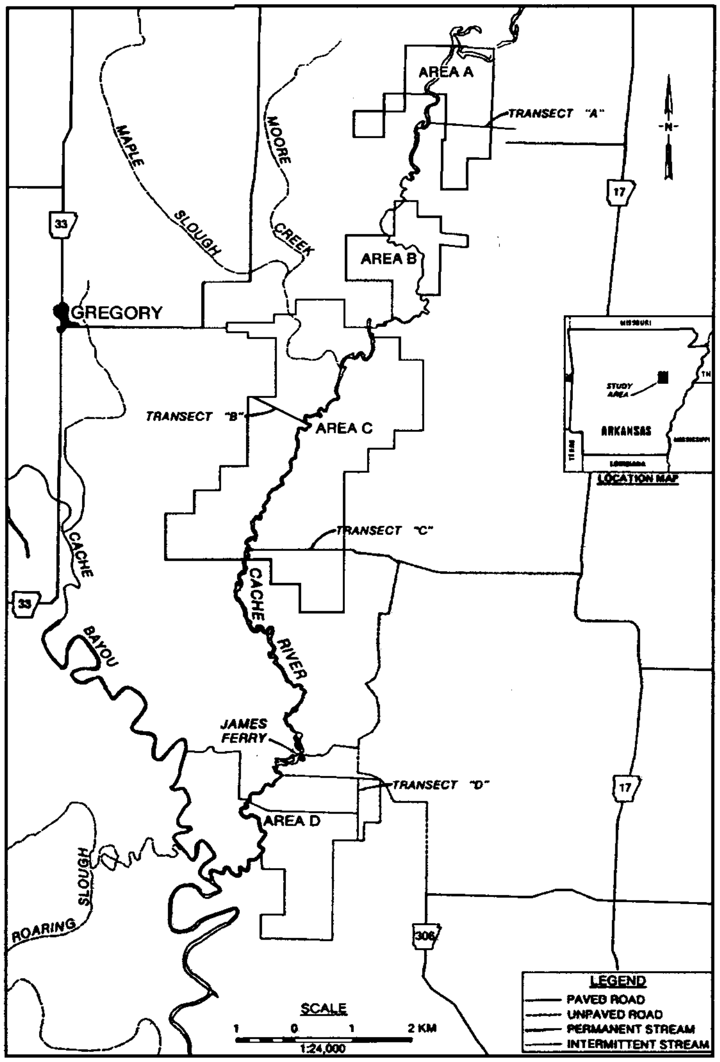

Figure 1. Cache River study areas

Traps in all arrays were run for a total of 22 days during May, August, and November 1988, and 29 days during June, August, October, and November 1990. Sampling periods were selected to represent a variety of seasons and water level conditions.

Over both years, 1,466 individuals were captured. A total of 11 mammal, 13 amphibian, and 6 reptile species were represented. Of these, 5 mammal, 10 amphibian, and 3 reptile species were captured in both 1988 and 1990.

During the three trapping periods of 1988, 810 individuals were captured. This included 9 mammal, 10 amphibian, and 5 reptile species. Live traps and snap traps provided 94 and 86 individuals, respectively, with all but 3 of these mammals. Seventeen percent of the small mammal captures were in traps on platforms in trees (38 individuals out of 223). Trap results for mammals were dominated by two species, the white-footed mouse (*Peromyscus leucopus*) and the cotton mouse (*P. gossypinus*). Pitfall traps yielded 630 individuals, primarily amphibians. Of the 810 total captures, 284 individuals were amphibians caught during May. The most commonly captured amphibians were the marbled salamander (*Ambystoma opacum*), green frog (*Rana clamitans*), and American toad (*Bufo americanus*). The most common reptile was the five-lined skink (*Eumeces fasciatus*).

Analysis of the 1990 data is not yet complete, but preliminary species lists have been compiled. There were 656 individual reptiles and amphibians captured, including 13 amphibian and 5 reptile species. In addition, there were 7 mammal species (plus unidentified *Peromyscus* and *Reithrodontomys*) captured. The southern leopard frog (*Rana sphenocephela*), green frog, and Woodhouse's toad (*Bufo woodhousei*) were the most common amphibians, and the five-lined skink was again the most common reptile.

Seasonal and yearly differences were seen in number of captures of some species of amphibians. For example, the marbled salamander was the dominant species captured in May and November 1988. They were absent in August 1988, June 1990, and August 1990, and only 12 were captured in November 1990. During both years, the green frog was more than twice as abundant in November than in other months. While rare in 1988, the southern leopard frog was the most common amphibian in 1990. The American toad was the most common toad in 1988, yet was greatly outnumbered by Woodhouse's toad in 1990.

BIRD SAMPLING: Bird surveys were conducted during the spring of 1988 and the winter of 1988-89. Two spring surveys were conducted on transects A and C, one in early April and another in mid to late May. The surveys were conducted approximately a month apart in order to examine use of the bottomland hardwood area by breeding resident species as well as early and late migrants. Each survey consisted of a count of birds within contiguous 60- by 80-m plots along the main and secondary (parallel) transects. There were 52 plots on the A transect and 58 on the C transect.

Two winter surveys were run only on the A transect. Sampling was conducted during mid-December, a period of low water, and during early March, a period of very high water. Approximately 75 percent of the plots were under water at the time of the March survey and much of the transect was surveyed using a canoe.

On most days, surveys were begun at or shortly after sunrise and lasted until midmorning. Some winter surveys were not begun until approximately an hour after sunrise when bird activity had increased. Surveys were conducted by slowly moving along each transect and tallying all birds present within the plot boundaries. The observers typically followed the center line of the transects; however, it was sometimes necessary to move throughout the plots to identify species or to determine a bird's location. Species were identified both visually and by calls. In some cases, identification to species was not possible and the genus (for example, *Empidonax*) or general group (for example, blackbirds (*Icteridae*)) was used.

Eighty-five species were identified during the study. There was considerable seasonal variation in the number of species; 68 species (plus unidentified *Empidonax*) were recorded during spring, but only 28 (plus unidentified blackbirds) were present during winter. Of those present during spring, 44 were considered to be resident breeders while 24 were migrants that breed in more northerly latitudes. Of the 44 resident species, 3, including the eastern kingbird (*Tyrannus tyrannus*), black-and-white warbler (*Mniotilta varia*), and red-winged blackbird (*Agelaius phoeniceus*), are not commonly found in bottomland hardwoods (James and Neal 1986). Most of the species identified from the site during winter, all but the Canada goose (*Branta canadensis*) and turkey vulture (*Cathares aura*), are considered to be winter residents of bottomland hardwoods in Arkansas (James and Neal 1986). Most of the species recorded during the spring and winter surveys were members of the order Passeriformes.

Numbers of species and individuals per plot varied widely. During spring the number of species per plot ranged from 7 to 21, while the number of individuals ranged from 9 to 34. Fewer species per plot were recorded during winter (range = 3-12) although, in some cases, the number of individuals per plot was much higher. For example, 3 plots contained over 200 individuals, primarily blackbirds.

WILDLIFE COMMUNITY HABITAT MODEL FOR BLH: Data from wildlife research on the Cache River were used to define the potential range of conditions for model variables, determine relative weights of each model variable, and refine the relationship between specific variable values and habitat quality. This is done through the analysis of habitat, wildlife, and hydrologic data. For example, the number of species whose occurrence is related to a specific moisture regime will help determine the weight given to that variable.

The draft wildlife community habitat model is designed to rate the quality of wildlife habitat in BLH and wooded swamps in the southeastern United States. Model output is a score ranging between 0.0 and 1.0, with a score of 1.0 corresponding with the habitat that supports the maximum species richness of birds, mammals, reptiles, and amphibians in BLH communities.

Optimum habitat is a large, relatively mature forest stand, with inherent diversity of stand types and variability in cover of various strata and tree sizes because of gaps, hydrologic variation, and topographic changes. The stand is subjected to a natural flooding cycle of water free of contaminants and comprises an unbroken tract of land bounded by nonurban land uses and largely undisturbed by human influence.

The range of conditions required by all species is expressed by variables at the plot and tract scale. Plot variables assess microhabitat and provide sample data for assessing internal conditions of the tract. Tract variables assess characteristics of the larger tract of BLH.

PLOT VARIABLES: Variables 1-8 are measured in the field on 0.04-ha plots. The number of plots is determined by the size of the tract and degree of homogeneity within the tract, and by the user's requirements for reliability of data. The following are plot variables.

- PV1 - Tree diameter. Average diameter of trees in the stand, with higher averages rated higher.
- PV2 - Overstory cover. Percent cover of live vegetation greater than 6 m tall in the overstory layer.
- PV3 - Mast types and variety. The diversity of tree species that produce hard and soft mast.
- PV4 - Old-growth elements. The number of items present in the plot that are found in old-growth forest stands; items are defined as objects or conditions that add structure and complexity to the habitat. The items are large trees, snags, large dead branches, trees with a basal or upper hollow, cavities, canopy vines, and epiphytes.
- PV5 - Moisture regime. An indication of the hydrologic zone, based on shrub species composition.
- PV6 - Understory cover. The percent cover of live vegetation between 1 and 6 m above the surface. This is the shrub layer, which includes species of trees that are less than 6 m tall.
- PV7 - Ground layer elements. The number of items present in a plot within 1 m of the surface; items are defined as objects or conditions that add structure and complexity to the ground layer. The items are leaf litter, woody debris, stumps, logs, live vegetation, root masses and brush piles, temporary water, and burrows.
- PV8 - Interspersion of moisture regimes. This is the degree of change across the tract (between plots) from wet to dry conditions, measured as distance to a topographic change.

TRACT VARIABLES: Variables 1-5 are measured based on the characteristics of the BLH tract and the surrounding area.

- TV1 - Core area factor. The area of an individual tract that is 100 m or more from a tract boundary that is bordered by nonforested habitat.

- TV2 - Isolation factor. A combination of two factors: permeability of the edge of a tract,that is, how different the adjacent cover types are, with upland deciduous forest being the most similar; and relative acreage of bottomland hardwoods in the vicinity. TV2 is calculated as the product of its two components.
- TV3 - Effective area. The measured area of the tract modified by the fragmentation factors for core area and isolation.
- TV4 - Water quality. The probability of poor water quality because of upstream or surrounding agricultural, industrial, or urban activities.
- TV5 - Disturbance. The probability of human disturbance lowering the quality of otherwise suitable habitat.

CALCULATIONS: The plot variables are converted to a Suitability Index (SI) on a scale of 0 to 1.0:

$$\frac{(PV1 \times PV2 \times PV3)^{1/2}}{3} + \frac{(PV4 \times PV6 \times PV7)^{1/2}}{3} + \frac{(PV5 \times PV8)^{1/2}}{3}$$

Each of the three components of the plot is considered necessary and weighted equally: tree layer (tree size, cover, and mast), additional structure (old-growth, understory, and ground elements), and hydrology (moisture regime, interspersion of wet and dry areas). No component may total greater than 0.34. Within each component, variables are weighted equally and can compensate for each other to some extent.

The tract SI is determined by modifying the Effective Area (TV3) SI by the adjustment factors for Water Quality (TV4) and Disturbance (TV5), as follows:

$$Tract\ SI = Effective\ Area\ SI \times Water\ Quality\ factor \times Disturbance\ factor$$

The Habitat Suitability Index (HSI) for the tract is the product of the tract and plot SIs.

The next step is to multiply area by HSI to obtain habitat units (HUs). HUs are determined for each of the five separate size classes of bottomland forests. This is necessary to prevent unintentional trade-off of large parcels for one or more smaller ones.

USE OF THE WILDLIFE COMMUNITY HABITAT MODEL IN BLH-WET: This approach to the wildlife function in BLH-WET is similar to the other functions in looking at the system holistically. The community model recognizes the importance of BLH to a large number of species and all vertebrate groups. It does not preclude application of HSI models for individual species or groups of species, if the user desires.

The output of 0 to 1.0 assumes a linear relationship between habitat quality and the number of species present in the evaluation area. The output should not be interpreted in relation to abundance of individuals, although it is generally true that as the number of species increases, so does the abundance of many individual species. The 0 to 1.0 scale can be reduced to classes (for example, low, moderate, and high), but there is a concurrent loss of information.

The model is structured to be flexible in its use. Some applications, such as a low-resolution comparison among tracts, can be done using just the tract-level variables, or using measured area with the appropriate tract size class SI curve. Data at the plot level can be measured or estimated, depending on the required precision of the answer.

The community model will be published as a Biological Report in the blue book HSI model series of the US Fish and Wildlife Service and as a miscellaneous paper of the WRP. It will be available to replace or supplement the wildlife function in WET-BLH.

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A Guild for Monitoring and Evaluating Fish Communities in Bottomland Hardwood Wetlands

PURPOSE: Documentation and ecological classification of fishes found in flooded wetlands are necessary to establish guidelines for evaluation and protection of these habitats. This paper summarizes adult and larval fish collections in the Rex Hancock/Black Swamp Wildlife Management Area, Cache River system, Arkansas, and classifies the fish community according to habitat preferences and modes of reproduction into a reproductive guild of fishes. This guild can serve as a basis in the selection of and evaluation of fish species for monitoring studies.

BACKGROUND: The Cache River originates just north of the Arkansas-Missouri state line and is part of the White River drainage. The basin covers approximately 2,018 square miles and is 143 miles long with a maximum width of 18 miles. The river flows 203 miles to its confluence with the White River near Clarendon, Arkansas. The river meanders across the floodplain, creating numerous cutoffs and side channels. In the vicinity of the study area, the forested floodplain ranges from 1 to 2 miles in width. Extensive areas of cypress-tupelo occur. As with many southeastern streams, flooding occurs by lateral expansion of the river onto the floodplain (Ross and Baker 1983). Flooding typically occurs from late February through May with intervening periods of drought and inundation of the floodplain. Water depths on the floodplain range from a few inches to more than 5 ft.

Fishes were collected from 1987 through 1989 in the river channel and floodplain of a fourth order reach of the Cache River. Four types of gear were used to sample juvenile and adult fishes: gill nets, hoop nets, seines, and a boat electroshocker. Larval fish were sampled regularly with three gears: tow net, light trap, and diaphragm pump.

COMPOSITION OF THE FISH COMMUNITY: The fish community consists of 71 species (Table 1), taxonomically dominated by minnows (16 species), sunfishes (15 species), darters (9 species), catfish (7 species), and suckers (6 species). Fishes of the Cache River are composed of a mixture of flood-exploitative species (i.e., those that exploit floodplain habitats) and flood-quiescent species (i.e., those that do not exploit floodplain habitats) whose movements may be influenced by hydrological factors such as turbidity and habitat availability (Ross and Baker 1983). Flood-exploitative species include blacktail shiner, grass pickerel, pirate perch, weed shiner, bluegill, green sunfish, blackspotted topminnows, and some darters; flood-quiescent species include longear sunfish, freshwater drum, and many darters. Other species characteristic of backwater habitats were also collected including pirate perch, flier, banded pygmy sunfish, and bantam sunfish. Species composition was typical of large, alluvial rivers in the lower Mississippi River basin (Cross, Mayden, and Stewart 1986).

DEVELOPMENT OF GUILD: A guild is a group of species that exploits the same environmental resources (e.g., habitats) in similar ways (Root 1967). Therefore, all members of a guild should be affected by the alteration of those resources (Roberts and O'Neil 1985). The Cache River guild of fishes is based on habitat preference and reproductive mode of adults. These criteria were used because water velocity and access to backwaters are directly modified by water resource projects, and the objective of many wetland restoration/creation projects is to provide spawning and rearing areas. Many bottomland hardwood fish species have specialized habitat requirements (Meffe and Sheldon 1988), so that changes in water velocity or access to backwaters could substantially impact populations. Most fishes have specific requirements for reproduction that are essential for their continued existence. Since reproductive failure in response to environmental stress can result in the rapid elimination of fish populations (Donaldson 1990), reproductive modes should be considered in evaluation of fish communities.

HABITAT CATEGORIES: A habitat classification of riverine systems by Baker, Killgore, and Kasul (1991) was used to define three distinct habitats in bottomland hardwood wetlands according to the position and size of the habitat, and the presence of flowing water. These are:

- Lentic-Oxbow Lakes, which are nonflowing habitats that include sloughs and oxbow lakes. They are permanent, floodplain waterbodies that are usually remnants of abandoned river channels. Most become contiguous with the main channel during floods. Size varies, ranging from several surface acres to greater than 500 acres. Large lakes are much deeper with a lower surface-to-volume ratio than floodplain ponds.

- Lentic-Floodplain Ponds, which are permanent floodplain ponds, but relatively shallow, isolated bodies of water. They form in floodways, in low points in intermittent tributaries, or in backswamp depressions. They are usually associated with cypress-tupelo stands. Ponds are usually less than one-tenth acre, less than 6 ft deep, with deep muddy substrates.

- Lotic-Channels, or flowing waterbodies, typically have sandbars and secondary channels. The substrate of these channels is usually sand with detritus deposited in the slackwater margins. Their depths and velocities are variable depending on channel morphology and instream cover.

REPRODUCTIVE MODES: Balon (1984) developed an evolutionary classification of reproductive modes that addressed behavior and substrate selection of fishes. In developing the Cache River Guild, fishes were classified according to four of Balon's (1984) reproductive modes that emphasized different substrates. These four reproductive modes are:

- Pelagophils, which are fishes that are nonguarding, egg-scattering, pelagic (open water) spawners. Eggs either float in the water column or move along the bottom.

- Litho-Psammophils, which are fishes that deposit eggs over sand or gravel. Some species guard the eggs from predators, while others exhibit no guarding behavior.

- Phytophils, which are fishes that deposit eggs on aquatic vegetation or woody debris. Eggs are often adhesive. Both guarding and nonguarding behavior is exhibited by adults.

- Speleophils, which are fishes that place their eggs in crevices, holes, under rocks, or in other types of structure to protect them from predators.

APPLICATION TO CACHE RIVER GUILD: Cache river fishes were assigned to one of the habitat categories and reproductive modes, resulting in 12 guilds (Table 2). Approximately 50 percent of the species prefer large, floodplain lakes and usually spawn on sand, gravel, or vegetation. Many of these species are recreationally or commercially important (e.g., bluegill, largemouth bass, smallmouth buffalo). However, most of the species in the lentic-large lake categories can tolerate a wide range of aquatic habitat conditions and are often considered habitat generalists. The most distinctive group of fishes associated with bottomland hardwood wetlands are in the lentic-floodplain pond categories (e.g., taillight shiner, flier, slough darter). There is evidence that some of these species can survive long periods of very low oxygen concentrations, perhaps explaining their dominance in this habitat (Baker, Killgore, and Kasul 1990; Leitman, Darst, and Nordhaus 1991). Species occurring in the lotic-channel category typically reside in areas with current as juveniles and adults, avoid habitats with excessive sedimentation, but often use the inundated floodplain during their larval stages.

USING THE GUILD FOR MONITORING AND EVALUATING: The initial step in habitat assessment studies is to identify all species in the study area, and from this list, select representative evaluation species for further analysis. The guild presented in this technical note includes many of the fish species that occur in bottomland hardwood river systems in the southeastern United States but can be revised for individual systems based on local fish surveys and on published life history studies. It can be used to select evaluation species that are most sensitive to particular habitat alterations (e.g. grass pickerel and taillight shiners to reductions in weedy floodplain ponds) and/or to maximize representation of the greatest number of ecologically similar species by choosing those from speciose guilds (e.g. spotted sucker and longear sunfish to represent habitat of 21 species).

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TABLE 1. Fish species collected from the channel (C) and floodplain (F) in the Cache River from 1987 through 1989. Juvenile and adult fishes were collected in November 1987, May 1988, July 1988, and May 1989. Larval fishes were sampled on six occasions during the spring of 1988 and 1989. An asterisk denotes species that were rarely collected (i.e., less than 10 individuals collected during the study).

Family and Species	Juvenile/Adult		Larvae	
	C	F	C	F
Petromyzontidae				
Chestnut lamprey (Ichthyomyzon castaneus)*	X			
Lepisosteidae				
Spotted gar (Lepisosteus oculatus)	X	X	X	X
Longnose gar (L. osseus)	X	X	X	
Shortnose gar (L. platostomus)	X	X		
Amiidae				
Bowfin (Amia calva)		X		
Anguillidae				
American eel (Anguilla rostrata)*	X			
Clupeidae				
Gizzard shad (Dorosoma cepedianum)	X	X	X	X
Threadfin shad (D. petenense)	X	X		
Esocidae				
Grass pickerel (Esox americanus)*		X		
Cyprinidae				
Blacktail shiner (Cyprinella venusta)	X	X	X	
Steelcolor shiner (C. whipplei)*	X			
Common carp (Cyprinus carpio)	X	X		X
Cypress minnow (Hybognathus hayi)*		X		
Central silvery minnow (H. nuchalis)	X	X		
Ribbon shiner (Lythrurus fumeus)	X	X	X	
Speckled chub (Macrhybopsis aestivalis)*	X	X		
Silver chub (M. storeriana)	X	X		
Golden shiner (Notemigonus crysocleucas)	X	X		X
Emerald shiner (Notropis atherinoides)	X	X	X	
Taillight shiner (N. maculatus)*	X	X		
Silverband shiner (N. shumardi)*	X			
Weed shiner (N. texanus)	X	X		
Mimic shiner (N. volucellus)*	X			
Pugnose minnow (Opsopoeodus emiliae)	X	X	X	
Bullhead minnow (Pimephales vigilax)	X	X	X	X

(Continued)

TABLE 1. (Continued)

Family and Species	Juvenile/Adult		Larvae	
	C	F	C	F
Catostomidae				
River carpsucker (Carpiodes carpio)	X		X	X
Quillback (C. cyprinus)*	X			
Smallmouth buffalo (Ictiobus bubalus)	X	X		X
Bigmouth buffalo (I. cyprinellus)	X			
Black buffalo (I. niger)*	X	X		
Spotted sucker (Minytrema melanops)	X	X	X	
Ictaluridae				
Black bullhead (Ameiurus melas)*		X		
Yellow bullhead (A. natalis)	X	X		X
Blue catfish (Ictalurus furcatus)*	X			
Channel catfish (I. punctatus)	X	X	X	X
Tadpole madtom (N. gyrinus)	X	X	X	X
Freckled madtom (N. nocturnus)*	X			
Flathead catfish (Pylodictis olivaris)	X			
Aphredoderidae				
Pirate perch (Aphredoderus sayanus)		X	X	X
Cyprinodontidae				
Blackspotted topminnow (F. olivaceus)		X	X	X
Northern starhead topminnow (F. dispar)*			X	
Poeciliidae				
Mosquitofish (Gambusia affinis)		X		
Atherinidae				
Brook silverside (Labidesthes sicculus)	X	X		
Inland silverside (Menidia beryllina)	X	X		
Percichthyidae				
White bass (Morone crysops)	X			
Yellow bass (M. mississippiensis)*	X			

(Continued)

TABLE 1. (Concluded)

Family and Species	Juvenile/Adult		Larvae	
	C	F	C	F
Centrarchidae				
Flier (Centrarchus macropterus)		X		X
Banded pygmy sunfish (Elassoma zonatum)		X	X	X
Warmouth (L. gulosus)	X	X		
Orangespotted sunfish (L. humilis)		X		
Green sunfish (Lepomis cyanellus)	X	X		
Bluegill (L. macrochirus)	X	X		X
Dollar sunfish (L. marginatus)		X		
Longear sunfish (L. megalotis)	X	X		
Redear sunfish (L. microlophus)	X	X		
Spotted sunfish (L. punctatus)*		X		
Bantam sunfish (L. symmetricus		X		
Largemouth bass (Micropterus salmoides)	X	X		
Spotted bass (M. punctulatus	X	X		
White crappie (Pomoxis annularis)	X	X	X	X
Black crappie (P. nigromaculatus)*	X			X
Percidae				
Mud darter (Etheostoma asprigene)		X	X	X
Bluntnose darter (E. chlorosomum)		X	X	X
Swamp darter (E. fusiforme)		X		
Slough darter (E. gracile)		X		X
Harlequin darter (E. histrio)*	X			
Cypress darter (E. proeliare)		X	X	X
Speckled darter (E. stigmaeum)	X	X	X	X
Logperch (Percina caprodes)	X	X		X
River darter (P. shumardi)	X		X	X
Sciaenidae				
Freshwater drum (Aplodinotus grunniens)	X	X	X	
TOTAL NUMBER OF SPECIES	**52**	**54**	**23**	**24**

TABLE 2. Guild of adult fishes occurring in bottomland hardwood wetlands. Species designations are based on Cache River collections and other literature cited in the text.

Reproductive Mode	Wetland Habitat		
	Lentic-Oxbow Lakes	**Lentic-Floodplain Ponds**	**Lotic-Channels**
Pelagophils	Gizzard shad Threadfin shad Silvery minnow Ribbon shiner	Mosquitofish Cypress minnow	American eel Speckled chub Silver chub Emerald shiner Mimic shiner Freshwater drum
Litho-Psammophils	River carpsucker Quillback Spotted sucker Warmouth Orangespotted sunfish Bluefill Redear sunfish Largemouth bass Spotted bass White crappie Black crappie	Pugnose minnow Spotted sunfish Bantam sunfish Flier Green sunfish Dollar sunfish Mud darter Bluntnose darter	Chestnut lamprey Silverband shiner Steelcolor shiner White bass Yellow bass Longear sunfish Harlequin darter Speckled darter Logperch River darter
Phytophils	Spotted gar Shortnose gar Bowfin Common carp Golden shiner Smallmouth buffalo Bigmouth buffalo Brook silverside	Grass pickerel Taillight shiner Northern starhead topminnow Blackspotted topminnow Banded pygmy sunfish Swamp darter Slough darter	Longnose gar Weed shiner Black buffalo Inland silverside
Speleophils	Bullhead minnow Black bullhead Yellow bullhead Channel catfish Tadpole madtom Flathead catfish	Pirate perch Cypress darter	Flacktail shiner Blue catfish Freckled madtom

Design and Application of a Larval Fish Trap

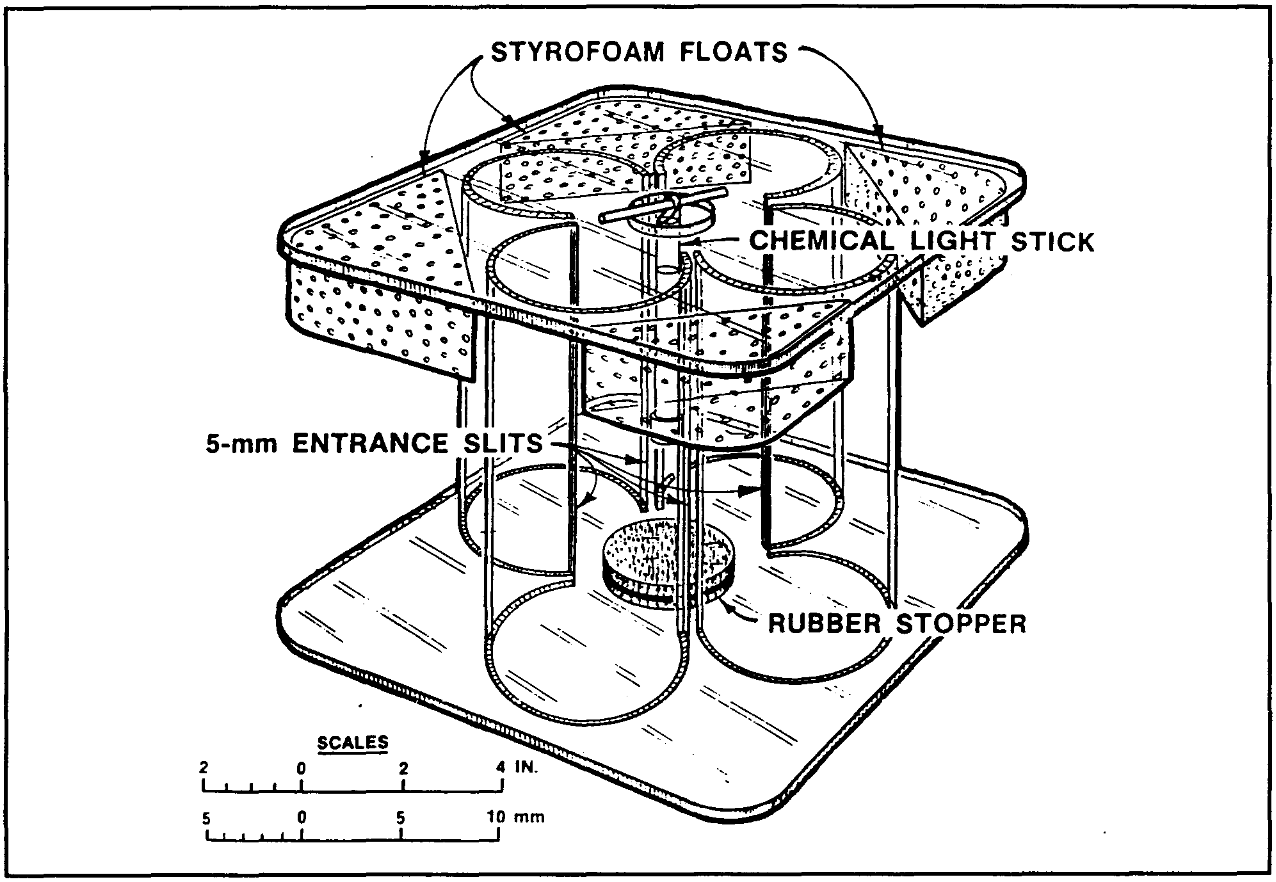

Figure 1. Larval Fish Trap

PURPOSE: This technical note describes construction of a light-activated Plexiglas trap used to collect larval fish. Since many fish are attracted to light, this type of collection method is useful to estimate abundance and to examine species composition of larval fishes. Light traps are ideal for sampling vegetated habitats such as wetlands and can be constructed in the laboratory or workshop.

DESIGN: The plan for the light trap (Fig. 1) is a modification of the Quatrefoil trap designed by Floyd et al. (1984). It is based on a slotted trapping system where four 5-mm entrance slots allow larval fish to enter the inner chamber. Once fishes are inside, they find it difficult to escape back through the narrow slots. One of the primary modifications to the original design is the use of a 12-hour, yellow Cyalume chemical lightstick for attracting fishes. This device eliminates the need for electrical power.

The base and top of the trap are solid pieces of 64 mm thick Plexiglas measuring 30.5 by 30.5 cm. A 2.5-cm hole is cut into the top plate for inserting the chemical light stick. The hole also provides an area where the trap can be grasped with a finger during retrieval. A 10.2 cm hole is cut in the bottom plate where a rubber stopper or cod end bucket is inserted. A removable rubber flange stopper is most efficient because it provides a tight seal, is easily removed for quick retrieval of larval fishes, and is readily available from plumbing supply stores. Four Plexiglas cylinders are cut longitudinally. Each tube is made of 64 mm thick Plexiglas and is 15- to 30 cm long. All four cylinders are glued to the top and bottom plates of Plexiglas with epoxy, allowing a 5 mm entrance slit between each cylinder.

Styrofoam is affixed to each corner of the top plate with epoxy, allowing the submersed trap to float on the water surface. A 2 mm hole is drilled into the top plate and a string is tied to the trap. The string is attached to a tree or stake to prevent the trap from floating away. If the trap cannot be tied off, an anchor line can be attached through a small hole drilled into the bottom plate. The cost per trap is relatively low (approximately $50).

TRAP APPLICATION: At least 30 traps can be transported to a sampling site in a 3-m canoe or flat bottom boat. Light traps are usually set at dusk and fished for predetermined time periods in order to derive catch per unit effort (CPUE). Traps are placed in the water with the activated light stick inserted into the trap.

After a preset time period, the boat is carefully brought up to the light trap and a plankton net is slowly positioned under the trap. The trap is gently lifted and the stopper removed. After the trap is washed several times to transfer fishes into the plankton net, it can be stored on the boat or placed back into the water for later pickup or resetting. The contents of the trap are washed through the plankton net into a cod end bucket attached to the net and fishes are transferred into a jar for preservation.

Depending on the needs of the experiment, light traps can be set a discrete depths to determine vertical occurrence of fishes. Dimensions of the trap and width of the entrance slits can be modified to meet various experimental requirements. For example, shorter traps (e.g., 15 cm long) are easier to transport in small boats and to sample shallow water.

SAMPLING CONSIDERATIONS: Light traps are a passive capture technique in that they remain stationary during the sampling period. If there is no water flowing through the trap, the water volume sampled is equivalent to the transmittance of light through the water column that is detectable and recognized by a stationary or moving phototactic fish. Turbidity and meteorological conditions affects light transmission. In addition, the phototactic behavior of larval fish, their temporal and spatial abundance, and the type of hydraulic regime in the sampling area directly influence encounter and collection rates. These factors result in considerable variation in catch using light traps and high sample sizes are required to reduce the variance.

Darters (*Family Percidae*), pirate perch (*Aphredoderidae*), minnows and shiners (*Cyprinidae*), and sunfishes (*Centrarchidae*) are best represented in light trap catches overall. The maximum number of larval fish collected in any one trap was over 2,000. Light traps have been successfully used to collect larval fish in riverine floodplains and littoral zones of reservoirs colonized by submersed aquatic plants. When spawning and rearing of fishes are components of environmental studies, light traps can provide life history data for many species of fish.

CONCLUSION: The information presented allows construction of light attributed fish traps and explains the best methods for their use in data collection/sampling.

REFERENCES:

Floyd, K. B., R. D. Hoyt, and S. Pimbrook. 1984. Chronology of appearance and habitat partitioning by stream larval fishes. Transactions of the American Fisheries Society 112: 280-285.

Killgore, K. J. and R. P. Morgan II. 1993. "Easily constructed light trap helps scientists collect larval fishes in wetlands." WRP Bulletin, Vol 3, No. 4, pp 1-4, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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Habitat Suitability Index Model Availability for Wetland Cover Types

PURPOSE: This technical note summarizes information from 66 Habitat Suitability Index (HSI) models for wildlife species that use wetland cover types. Items of information include the specific wetlands for which the models apply, States in which the species occur, and taxonomic groupings. The information is presented in a series of tables, so that users can quickly determine the number and variety of HSI models available for application in wetland habitats in their geographic work area. The data presented apply only to wildlife species and do not include HSI models for fish species.

BACKGROUND: Wetland protection has emerged as an important concern in environmental planning across the United States (Steiner and others 1994). Federal and State regulatory agencies must assess impacts to these wetlands and determine the need for alternative plans or mitigation. The Habitat Evaluation Procedures (U.S. Fish and Wildlife Service 1980) and Habitat Suitability Index (HSI) models (Schamberger, Farmer, and Terrell 1982) are useful tools in quantifying habitat value for fish and wildlife and comparing project or mitigation alternatives. Over 150 HSI models have been developed for a wide range of species that occupy upland, wetland, and aquatic habitats.

Only models published in the U.S. Fish and Wildlife Service's Biological Report Series (Schamberger, Farmer, and Terrell 1982) are reviewed.

HSI MODELS FOR WETLAND TYPES: The cover type classification system developed for HSI models contains 10 specific types for wetland and deepwater habitats (Table 1) (U.S. Fish and Wildlife Service 1981), and this system will be used to describe wetland HSI model availability. The wetland classification system developed by Cowardin and others (1979) contains much more detail than the HSI model system. The relation of the 10 HSI model wetland cover types to the wetland classification system developed by Cowardin and others (1979) is described in Appendix E of the U.S. Fish and Wildlife Service (1981) manual. Users are encouraged to review this appendix to gain a more thorough understanding of the similarities and differences between the two systems.

Of the first 17 models developed in the HSI model series, none applied to wetland cover types. Wetland models, however, are well represented in the remainder of the series, and comprise 10 of the last 17 published models. The herbaceous wetland cover type has the most species HSI models available (n = 37), followed by deciduous forested wetlands (n = 33), deciduous scrub-shrub wetlands (n = 26), and lacustrine wetlands (n = 25) (Table 2). Evergreen wetland types have fewer models than their deciduous counterparts (EFW has 22 and ESW, 16 versus DFW, 33 and DSW, 26). The marine wetland cover type has the fewest (n = 5) models available.

Seventeen HSI models have only a single wetland cover type listed for which the model applies, with seven of these restricted to the estuarine type. Ten HSI models apply to seven or more wetland cover types. There are a number of wildlife species more typically thought of as "upland" species that also use wetland types. For example, the fox and gray squirrel models can both be applied in deciduous forested wetlands, and herbaceous wetlands may provide nesting cover for the greater prairie-chicken. However, most wetland HSI models are for species typically thought to be closely associated with wetland habitats.

Table 1
Wetland Cover Type Classification System Used for HSI Models (U.S. Fish and Wildlife Service 1981)

Wetlands
    Forested wetlands
        Evergreen forested wetland (EFW)
        Deciduous forested wetland (DFW)
    Scrub-shrub wetlands
        Evergreen scrub-shrub wetland (ESW)
        Deciduous scrub-shrub wetland (DSW)
    Herbaceous wetland (HW)
    Shore, bottom wetland (SBW)

Deepwater habitats
    Riverine (R)
    Lacustrine (L)
    Estuarine (E)
    Marine (M)

HSI MODELS FOR GEOGRAPHIC AREAS: Information on the geographic distribution of HSI models was obtained from the models, when included there, or from checklists and field guides. Forty-nine of the 50 States have HSI models available for some wetland cover type (Table 3). Hawaii is the only State with no HSI wetland models. States with 35 or more wetland models available are Alabama, Louisiana, Minnesota, Mississippi, North Carolina, South Carolina, and Texas. States with fewer than 25 wetland models are Alaska, Arizona, Nevada, New Mexico, New York, Rhode Island, Utah, and West Virginia. For some species, the HSI models were not developed to cover the entire geographic range of the species. Thus, some of the species in Table 3 occur in more States than are listed, but the listed States accurately reflect the coverage described in the HSI model.

Twenty-six of the 66 species models apply to 10 or fewer States, and 17 apply to 40 or more States. The following widely distributed species apply to all States except Hawaii:

Beaver	Hairy woodpecker
Belted kingfisher	Muskrat
Downy woodpecker	Red-winged blackbird
Great blue heron	

The U.S. Fish and Wildlife Service divides the conterminous United States into six regions (Figure 1). Regions 2 and 4 have the most HSI wetland models available (52 and 53, respectively), primarily because of the large number of models in those regions that apply to the estuarine cover type (Table 4). Region 1 has the fewest wetland models available (31). Deciduous forested wetlands and herbaceous wetlands have the most models in each of the six regions.

HSI MODELS BY TAXONOMIC GROUPS: Birds are the dominant taxonomic group in wetland HSI models, comprising 70 percent of the 66 wetland models. The percentages of other major taxonomic groups are as follows: mammals (18 percent), reptiles and amphibians (8 percent), and invertebrates (4 percent). Within the bird group, the breakdown of major groups of species models is:

Table 2
Matrix of Wetland HSI Models and the Wetland Cover Types to Which They Apply

Species Name and Publication Number	DFW	EFW	DSW	ESW	SBW	HW	L	R	E	M
Red-spotted newt (111)	X					X	X			
Bullfrog (138)	X	X	X	X	X	X	X	X		
Snapping turtle (141)	X	X	X	X	X	X	X			
Slider turtle (125)	X		X			X	X	X		
American alligator (136)					X	X			X	
Western grebe (69)						X				
Eastern brown pelican (90)									X	X
Great blue heron (99)	X	X	X	X	X	X	X	X	X	
Great egret (78)	X	X	X	X	X	X		X	X	
Roseate spoonbill (50)	X		X						X	
White ibis (93)	X	X	X	X	X	X			X	
Wood duck (43)	X		X			X		X		
Northern pintail (145)					X	X	X			
Northern pintail (Gulf coast wintering) (121)					X	X	X		X	
Blue-winged teal (breeding) (114)					X	X	X			
Mottled duck (52)			X		X	X			X	
Mallard (winter habitat) (132)	X		X		X	X	X	X		
American black duck (wintering) (68)									X	X
Gadwall (breeding) (100)					X	X	X			
Greater white-fronted goose (wintering) (116)					X	X				
Lesser scaup (wintering) (91)					X	X	X		X	X
Lesser scaup (breeding) (117)						X	X			
Redhead (wintering) (53)									X	

(Sheet 1 of 3)

Table 2 (Continued)

Species Name and Publication Number	DFW	EFW	DSW	ESW	SBW	HW	L	R	E	M
Black brant (63)									X	
Canvasback (breeding) (82)			X			X	X			
Lesser snow goose (wintering) (97)					X	X	X		X	
Black-bellied whistling-duck (breeding) (150)	X		X			X	X			
Osprey (154)	X	X	X	X		X	X	X		
Black-shouldered kite (130)						X				
Bald eagle (breeding season) (126)							X		X	
Greater prairie-chicken (102)						X				
Eastern wild turkey (106)	X									
American coot (115)						X	X	X		
Clapper rail (51)									X	
Greater sandhill crane (140)	X	X	X	X	X	X	X	X		
American woodcock (wintering) (105)	X	X	X	X						
Laughing gull (94)									X	
Least tern (103)					X		X	X	X	X
Forster's tern (breeding) (131)									X	
Barred owl (143)	X	X								
Belted kingfisher (87)							X	X		
Pileated woodpecker (39)	X	X								
Lewis' woodpecker (32)	X									
Downy woodpecker (38)	X	X								
Hairy woodpecker (146)	X	X								
Black-capped chickadee (37)	X	X								

(Sheet 2 of 3)

Table 2 (Concluded)

Species Name and Publication Number	DFW	EFW	DSW	ESW	SBW	HW	L	R	E	M
Marsh wren (139)			X	X		X	X	X	X	
Veery (22)	X	X	X							
Yellow warbler (27)			X							
Red-winged blackbird (95)						X				
Yellow-headed blackbird (26)						X				
Black bear (144)	X	X	X	X		X				
Fisher (45)	X	X								
Mink (61) (127-R)	X	X	X	X		X	X	X		
Bobcat (147)	X		X							
Moose (155)	X	X	X	X		X	X	X		
White-tailed deer (123)	X	X	X	X		X				
Gray squirrel (19) (135-R)	X									
Fox squirrel (18)	X									
Beaver (30)	X	X	X	X		X	X	X		
Muskrat (46)						X		X	X	
Snowshoe hare (101)	X	X	X	X						
Swamp rabbit (107)	X	X	X	X		X				
Gulf of Mexico American oyster (57)									X	
Hard clam (77)									X	
Littleneck clam (59)									X	X
Total for cover type	33	22	26	16	17	37	25	17	23	5

(Sheet 3 of 3)

Table 3
Matrix of Wetland HSI Models and the States in Which Each Species Occurs

Species Name (USFWS Publication Number)	State of Occurrence (Alabama-Montana)																								
	AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
Red-spotted newt (111)	X						X	X					X			X	X	X	X	X	X		X		
Bullfrog (138)	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X
Snapping turtle (141)	X			X		X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X
Slider turtle (125)	X			X					X	X		X	X	X	X	X	X						X	X	
American alligator (136)	X								X								X						X		
Western grebe (69)					X	X					X			X								X			X
Eastern brown pelican (90)									X								X								
Great blue heron (99)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great egret (78)	X								X	X							X						X		
Roseate spoonbill (50)	X								X								X						X		
White ibis (93)	X								X	X							X						X		
Wood duck (43)	X			X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Northern pintail (145)														X								X			X
Northern pintail (Gulf coast wintering) (121)																	X								
Blue-winged teal (breeding) (114)														X								X			X
Mottled duck (52)																	X								
Mallard (winter habitat) (132)				X								X				X	X						X	X	
American black duck (wintering) (68)								X											X						

(***Sheet 1 of 8***)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Alabama-Montana)																								
	AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
Gadwall (breeding) (100)																						X			X
Greater white-fronted goose (wintering) (116)																	X								
Lesser scaup (wintering) (91)	X								X	X							X							X	
Lesser scaup (breeding) (117)	X				X						X											X			X
Redhead (wintering) (53)	X								X								X						X		
Black brant (63)					X																				
Canvasback (breeding) (82)																						X			X
Lesser snow goose (wintering) (97)	X																X						X		
Black-bellied whistling-duck (breeding) (150)																									
Osprey (154)	X				X	X	X	X	X	X	X						X	X	X	X	X	X			X
Black-shouldered kite (130)					X																				
Bald eagle (breeding season) (16)					X	X	X	X			X	X	X	X	X	X		X	X	X	X	X		X	X
Greater prairie-chicken (102)				X		X						X	X	X	X						X	X		X	
Eastern wild turkey (106)				X			X	X		X		X	X	X	X	X	X	X	X	X	X	X	X	X	

(Sheet 2 of 8)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Alabama-Montana)																								
	AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
American coot (115)		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Clapper rail (51)	X				X		X	X	X	X							X		X	X			X		
Greater sandhill crane (140)					X	X					X	X	X								X	X			X
American woodcock (wintering) (105)	X			X					X	X							X						X		
Laughing gull (94)	X								X								X						X		
Least tern (103)	X			X	X	X	X	X	X	X				X	X	X	X	X	X	X			X	X	
Forster's tern (breeding) (131)																	X		X						
Barred owl (143)	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Belted kingfisher (87)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pileated woodpecker (39)	X			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Lewis' woodpecker (32)			X		X	X					X														X
Downy woodpecker (38)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hairy woodpecker (146)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black-capped chickadee (37)		X			X	X	X	X			X	X	X	X	X	X		X	X	X	X	X		X	X
Marsh wren (139)	X		X		X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X	X
Veery (22)			X			X	X	X			X		X					X	X	X	X	X			X
Yellow warbler (27)	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Red-winged blackbird (95)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

(Sheet 3 of 8)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Alabama-Montana)																								
	AL	AK	AZ	AR	CA	CO	CT	DE	FL	GA	ID	IL	IN	IA	KS	KY	LA	ME	MD	MA	MI	MN	MS	MO	MT
Yellow-headed blackbird (26)			X		X	X					X	X	X	X	X							X		X	X
Black bear (144)																					X	X			
Fisher (45)					X		X				X							X		X	X	X			X
Mink (61) (127-R)	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bobcat (147)	X			X				X	X	X							X		X				X	X	
Moose (155)																					X	X			
White-tailed deer (123)				X					X	X						X	X						X		
Gray squirrel (19) (135-R)	X			X			X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	
Fox squirrel (18)				X		X		X		X		X	X	X	X	X			X		X	X	X	X	X
Beaver (30)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Muskrat (46)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Snowshoe hare (101)	X	X			X	X	X	X			X							X	X	X	X	X			X
Swamp rabbit (107)				X						X		X			X	X	X						X	X	
Gulf of Mexico American oyster (57)	X								X								X								
Hard clam (77)	X						X	X	X	X							X	X	X	X			X		
Littleneck clam (59)		X			X																				
Total for state	35	13	14	26	30	27	28	30	33	31	26	27	27	28	25	26	42	27	31	28	30	35	36	29	32

(Sheet 4 of 8)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Nebraska-Wyoming)																							
	NE	NV	NH	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
Red-spotted newt (111)			X	X		X	X		X			X		X		X			X	X		X		
Bullfrog (138)	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Snapping turtle (141)	X		X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X		X	X	X
Slider turtle (125)					X		X			X				X		X	X			X				
American alligator (136)																	X							
Western grebe (69)	X	X			X			X			X				X			X			X			X
Eastern brown pelican (90)							X							X			X							
Great blue heron (99)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Great egret (78)							X							X			X							
Roseate spoonbill (50)																	X							
White ibis (93)							X							X			X							
Wood duck (43)	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	
Northern pintail (145)								X							X									
Northern pintail (Gulf coast wintering) (121)																	X							
Blue-winged teal (breeding) (114)	X							X							X									X
Mottled duck (52)																	X							
Mallard (winter habitat) (132)																X								
American black duck (wintering) (68)				X			X													X				

(Sheet 5 of 8)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Nebraska-Wyoming)																							
	NE	NV	NH	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
Gadwall (breeding) (100)								X							X									
Greater white-fronted goose (wintering) (116)																	X							
Lesser scaup (wintering) (91)							X							X			X							
Lesser scaup (breeding) (117)	X	X						X			X				X			X			X			X
Redhead (wintering) (53)																	X							
Black brant (63)											X										X			
Canvasback (breeding) (82)								X							X									
Lesser snow goose (wintering) (97)																	X							
Black-bellied whistling-duck (breeding) (150)																	X							
Osprey (154)		X	X	X	X	X	X				X		X	X			X	X	X	X	X		X	X
Black-shouldered kite (130)																	X							
Bald eagle (breeding season) (16)	X	X	X	X		X		X	X		X	X	X		X			X	X	X	X	X	X	X
Greater prairie-chicken (102)	X							X	X	X					X		X						X	
Eastern wild turkey (106)	X		X	X		X	X	X	X	X		X	X	X	X	X	X		X	X		X	X	

(Sheet 6 of 8)

Table 3 (Continued)

Species Name (USFWS Publication Number)	State of Occurrence (Nebraska-Wyoming)																							
	NE	NV	NH	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
American coot (115)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Clapper rail (51)			X	X			X					X		X			X			X				
Greater sandhill crane (140)		X									X							X					X	X
American woodcock (wintering) (105)							X			X				X		X	X			X				
Laughing gull (94)																	X							
Least tern (103)	X			X	X		X	X		X				X	X	X	X			X				
Forster's tern (breeding) (131)				X			X										X			X				
Barred owl (143)	X		X	X		X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
Belted kingfisher (87)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Pileated woodpecker (39)			X	X		X	X	X	X	X	X	X	X	X		X	X		X	X	X	X	X	
Lewis' woodpecker (32)		X			X						X							X			X			X
Downy woodpecker (38)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Hairy woodpecker (146)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Black-capped chickadee (37)	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X		X	X	X	X	X	X	X
Marsh wren (139)	X	X	X	X		X	X	X	X	X	X	X	X	X	X		X		X	X	X		X	X
Veery (22)		X	X	X		X	X	X	X		X	X	X		X			X	X	X	X	X	X	X
Yellow warbler (27)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X	X	X

(Sheet 7 of 8)

Table 3 (Concluded)

Species Name (USFWS Publication Number)	State of Occurrence (Nebraska-Wyoming)																							
	NE	NV	NH	NJ	NM	NY	NC	ND	OH	OK	OR	PA	RI	SC	SD	TN	TX	UT	VT	VA	WA	WV	WI	WY
Red winged blackbird (95)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Yellow-headed blackbird (26)	X	X			X			X	X		X				X			X			X			X
Black bear (144)																							X	
Fisher (45)		X	X			X					X								X		X	X	X	
Mink (61) (127-R)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Bobcat (147)							X							X		X	X			X				
Moose (155)																							X	
White-tailed deer (123)							X							X		X	X			X				
Gray squirrel (19) (135-R)	X		X	X		X	X	X	X	X		X	X	X		X	X		X	X		X	X	
Fox squirrel (18)	X			X			X	X	X	X		X		X	X	X	X			X		X	X	
Beaver (30)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Muskrat (46)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Snowshoe hare (101)	X	X		X	X		X		X	X	X	X		X	X		X	X	X	X	X	X	X	X
Swamp rabbit (107)										X				X		X	X							
Gulf of Mexico American oyster (57)																	X							
Hard clam (77)			X	X			X						X	X			X			X				
Littleneck clam (59)											X										X			
Total for state	27	23	26	30	20	24	37	30	26	25	28	25	23	35	30	27	45	21	25	34	27	24	29	25

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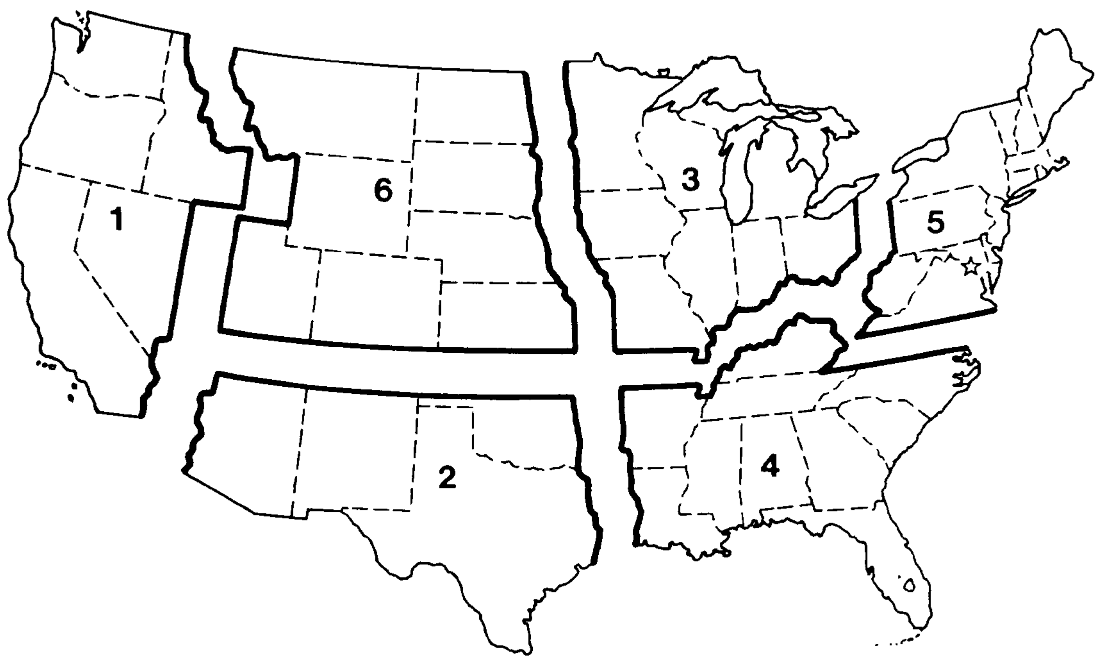

Figure 1. Division of conterminous United States into six USFWS regions

Table 4
Matrix of Wetland HSI Models and the U.S. Fish and Wildlife Service Regions of the Conterminous United States

	Number of Wetland HSI Models per Cover Type										
Region	**DFW**	**EFW**	**DSW**	**ESW**	**SBW**	**H**	**L**	**R**	**E**	**M**	**Total**
1	16	14	11	8	4	15	12	12	8	4	31
2	27	18	21	13	12	27	17	14	20	4	52
3	27	19	20	13	9	27	21	16	5	2	43
4	28	19	22	14	13	28	20	16	21	4	53
5	24	17	16	11	4	17	14	14	9	3	38
6	23	16	16	10	9	23	19	14	6	4	40

Ducks and geese	16 models
Passerines	6 models
Herons and allies	4 models
Raptors	4 models
Woodpeckers	4 models
Gulls and terns	3 models

Ducks and geese comprise almost one fourth of all wetland HSI models, and these 16 models (14 species) account for 23 percent of the 61 species of ducks and geese in North America (American Ornithologists' Union 1983). Shorebirds are very poorly represented in the HSI model series. There are 84 different species of shorebirds in North America (American Ornithologists' Union 1983), but only one HSI model exists for a shorebird (American woodcock).

The 12 species models for mammals consist of four carnivores, four rodents, two ungulates, and two lagomorphs. No small mammals (mice, voles, etc.) are represented in the mammal wetland models. Reptiles and amphibians are poorly represented in the wetland HSI models, with only five species, mostly from freshwater cover types. In some areas of the United States (for example, the Southeast), reptiles and amphibians comprise a high percentage of the total number of vertebrate species and are strongly associated with wetland types. The increasing concern with the reptile and amphibian vertebrate groups has been widely expressed (Beiswenger 1988, Gibbons 1988, Wyman 1990), and the lack of HSI models for these species represents a significant gap in the HSI model series. There are only three invertebrate species HSI models, none of which occurs in fresh water.

The availability of wetland HSI models appears to reflect both the political importance of species during the time the models were being developed and the amount of habitat information available for model development. From a taxonomic viewpoint, birds are overrepresented and all other groups are underrepresented in HSI models for wetlands. Within the bird HSI models, ducks and geese are the dominant group, comprising over one third of the bird wetland models. Groups such as amphibians, neotropical migratory birds, shorebirds, and invertebrates, which are of growing interest to ecologists, are poorly represented in the HSI model series.

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Weaver Bottoms Wildlife Habitat Restoration: A Case Study

PURPOSE: This technical note evaluates the success of a wetland rehabilitation project in the first four years following construction. Backwater areas of the Upper Mississippi River provide important feeding and resting areas for migratory waterfowl, and habitat quality deterioration of these highly productive marshes has been a cause of great concern. The Weaver Bottoms Rehabilitation Project is a large scale wetland restoration project that is directed at regaining lost habitat by creating hydrological and energy conditions conducive to marsh growth and production. Davis et al. (1993) presents the Phase I pre-project (1985-87) and post-construction (1988-91) monitoring results and assesses project impacts on the Weaver Bottoms aquatic system during the first three years following construction. This technical note summarizes that report.

BACKGROUND: In the early 1930's, the U.S. Army Corps of Engineers constructed a series of locks and dams in the Upper Mississippi River to improve commercial navigation along the 848 river miles from Cairo, IL to Minneapolis, MN. Extensive areas of the UMR's floodplain were inundated and rapidly became highly productive backwater marshes. Since the early 1960's, however, aerial coverage and density of wetland vegetation have fluctuated and gradually declined, reducing many backwater marshes to open, windswept, riverine lakes with low fish and wildlife habitat quality.

The Great River Environmental Action Team I was organized in 1973 with representatives from the Army Corps of Engineers, U.S. Fish and Wildlife Service, Wisconsin, and Minnesota to identify and assess the problems associated with multipurpose use of the UMR and to develop recommendations for improved management of its resources. Weaver Bottoms, a 4,000-acre backwater area in Pool 5 of the UMR located between southeastern Minnesota and southwestern Wisconsin, was selected as a representative area for extensive study. It was determined that habitat quality deterioration was due to loss of marsh vegetation. The inability of marsh vegetation to recover was attributed to a variety of reasons, including two major floods in the late 1960's, uprooting and removal of plants by wind and ice, changed flow and sedimentation patterns, and reduced water clarity caused by wind-induced wave resuspension of sediments.

As a result, the Weaver Bottoms Rehabilitation Project was designed to reduce Mississippi River flows entering the backwater by modifying side channels and to reduce wind fetch and re-suspension of bottom sediments by creating barrier islands. Also, the project was to reduce maintenance dredging requirements in the navigation channel and provide long-term dredged material storage. Phase I construction at Weaver Bottoms was completed by mid 1987. Partial or complete closures were constructed across most of the secondary channels leading from the Mississippi River into the area with two 16-acre islands constructed in open waters (Fig. 1). Phase II will be implemented after the effects of Phase I construction have been evaluated.

A comprehensive, 10-year Resource Analysis Plan outlines how to monitor these Phase I project effects. The plan is based on an interagency Memorandum of Understanding, designating the U.S. Fish and Wildlife Service as the lead agency and providing for active participation from the U.S. Army Corps of Engineers, and Wisconsin and Minnesota Departments of Natural Resources.

MONITORING RESULTS: The Resource Analysis Plan established a 10-year monitoring program to assess project impacts on hydrodynamics, sedimentation, water quality, emergent and aquatic vegetation, use of aquatic and wildlife habitats by birds, fish, and mammals, and recreational use. Results from the first 6 years (1986-1992) of the monitoring program are summarized below.

- Hydrodynamics. Monitoring indicated that secondary channel discharges to Weaver Bottoms were reduced 80 percent, and hydraulic residence time was increased 2 to 6 times (from 3 days to 7.6 days in isolated portions) after construction. Current velocities within Weaver Bottoms have been reduced a similar order of magnitude (60-90 percent). The two constructed islands have altered flow patterns; but wave action continues to be a major factor influencing bottom velocities and sediment resuspension. Hydrodynamic impacts of the islands on Weaver Bottoms are small compared to the reduction in inflow due to closure of secondary channels.

  There was concern that diversion of flow from Weaver Bottoms would adversely affect adjacent areas of Pool 5. Data indicate that for total river discharges less than 60,000 cfs (greatest flow during the monitoring period), secondary channel discharges, current velocities, and water surface elevations in areas outside of Weaver Bottoms have not been affected.

  Overall dredging requirements in the navigation channel near Weaver Bottoms have decreased by 60 percent following project construction. The decrease in dredging requirements during the study period was probably due to greater channel scouring with increased river flows diverted from Weaver Bottoms into the main river channel.

- Sedimentation. Bathymetry data were collected pre-project in 1986 and post-project in 1991; 1935 data were also used in the analysis. Construction resulted in notable changes in erosion/deposition patterns in Weaver Bottoms. Although the net change in bathymetry from 1986 to 1991 was small, high rates of both deposition and erosion occurred, indicating that internal factors such as wind generated wave action have increased their influence on the sedimentation patterns in Weaver Bottoms.

  General patterns show deposition in deep areas and erosion in shallow areas. Three areas showed the greatest change in bathymetry since project construction. First, the Pritchard Maloney area (Fig. 1), that historically has shown substantial erosion since inundation, has now become a depositional zone, with water depths reduced from a mean of 108 to 90 cm. Second, the delta areas at side channel openings along the main channel side of Weaver showed both deposition and erosion. For instance, from 1986 to 1991 as much as 90 to 120 cm of deposition occurred near remaining inlets to Weaver Bottoms; however, there was erosion of downstream portions of the inlet deltas. The other area that showed a great deal of change was near the mouth of the Whitewater River. In a 1990 Whitewater River study, increased rates of delta expansion were found to be a function of reduced flow velocities into Weaver Bottoms following project construction.

  Sedimentation rates from 1935 to 1986 were estimated between 0.18 to 0.22 cm/year, with a net loss in water volume between 12 to 13.8 percent. Limitations with 1991 bathymetric data did not allow for a comparison of post-project sedimentation rates.

- Water Quality. A project objective was increased water clarity for improved conditions for vegetation growth, however, neither suspended solids or turbidity levels were reduced. Reduction of inflow from the Mississippi River reduced mixing and flushing rates in Weaver Bottoms. Water quality in downstream portions of the backwater area became more influenced by the Whitewater River, a turbid river which empties directly into Weaver Bottoms (Fig. 1). Variation (heterogeneity) in water quality values increased among areas within Weaver Bottoms after project construction. Water quality in Weaver Bottoms did not improve within the first 3 years following construction. Completion of the 10-year monitoring program will allow better determination whether this project-induced heterogeneity is long or short term.

- Vegetation. Between 1985 and 1990, a general decline in emergent and submergent aquatic vegetation was recorded in the Weaver Bottoms Rehabilitation Project area. Total emergent vegetation biomass decreased from 4069 g/m^2 in 1985 to 1151 g/m^2 in 1990. Mean above ground wet weight for submergents decreased from 1404 g/m^2 in 1985 to 5 g/m^2 in 1990. The cause of the vegetation loss is unclear but is apparently related to the 1987-89 drought and not due to project construction. Drastic vegetation losses similar to those documented in this study have been noted in Pool 7 and other Upper Mississippi River pools during the same time period.

- Birds and Mammals. Aerial waterfowl transect surveys were conducted each fall from 1985 through 1990. Peak waterfowl numbers usually occurred on Pool 5 in late October. Waterfowl use-days increased substantially between 1986 and 1987, but sustained a steady decline during the remaining post-construction period of 1988-90. Annual diving duck (mostly canvasback, *Aythya valisineria*) use-days were more than double that of puddle ducks during the 1985-87 period, but were below or nearly equal to puddle duck use-days 1988-90. This post-construction decline in diving duck use probably reflected the drastic losses of American wildcelery (*Vallisneria americana*), a preferred canvasback food, in Weaver Bottoms during 1989 and 1990. Total use-days of tundra swan (*Cygnus columbianus*), another common migratory waterfowl in the area, varied but were lowest in 1989 and 1990 when substantial declines in arrowhead (*Sagittaria* spp.) biomass were detected.

  The waterfowl and vegetation declines at Weaver coincide with those observed on Pool 7 where wildcelery acreage plummeted from 3,500 acres in 1987 to less than 300 acres in 1989. Losses in vegetation and waterfowl use on the Weaver Bottoms project area were not attributable to the rehabilitation project, as evidenced by similar losses in nearby Upper Mississippi River pools. Changes in continental populations, habitat conditions, and weather influenced migratory bird use of the river. The occurrence of muskrat (*Ondatra zibethica*), shorebirds, gulls, and terns on Weaver Bottoms was monitored but no population trends were detected.

- Fish. Fish populations were monitored within and outside the Weaver Bottoms project area. Trap nets, experimental gill nets, and electroshocking methods were used. Pre-construction sampling yielded 9,323 fish representing 69 species with an average weight of 264 g/fish. Post-construction sampling yielded 16,992 fish, representing 57 species with a higher average weight of 271 g/fish. All sample methods showed an increase in catch per unit effort during the post-construction years. The proportion of sport fish, rough fish, and forage fish captured, showed little change between pre- and post-construction periods.

	By Number		By Weight	
	Pre	Post	Pre	Post
Sport fish	56%	61%	34%	32%
Rough fish	23%	22%	62%	66%
Forage fish	21%	17%	2%	2%

Proportions of fish initially caught during the pre-project and post-construction Weaver Bottoms RAP monitoring program represented by major guilds of the Upper Mississippi River.

Four species were identified as key species in the Weaver Bottoms Resource Analysis Plan: northern pike (*Esox lucius*), carp (*Cyprinus carpio*), bluegill (*Lepomis macrochirus*), and black crappie (*Pomoxis nigromaculatus*). Gill netting data show a biomass increase for all four species in the post-construction period with carp increasing the most. Similar increases in catch per unit effort for the four species at stations within and outside Weaver Bottoms indicate that population increases may be partially due to factors other than the rehabilitation project.

- Recreation. Estimates of recreational activity in Pool 5 were made by passive observations at water recreation accesses to Pool 5, boat patrols counting visitors, aerial surveys, and use of recreational lockage figures in 1986, '87 and '89. The Weaver Bottoms project has had little detectable effect on recreational use of Pool 5 thus far. A few new beaches created at closures attract some use.

CONCLUSIONS: Although the findings from the Weaver Bottoms Resource Analysis Program presented in this technical note are preliminary, several important results can be used to improve future efforts to restore river backwater areas. The first outcome of this project indicates the need to identify and treat all causes of habitat degradation to facilitate natural recovery. Wind and current energy in Weaver Bottoms clearly caused physical damage to the plants as well as turbid water, but there were other factors that contributed to the vegetation decline. The plants were unable to recover in Weaver Bottoms after project construction because they were continually weakened by additional stresses such as carp and pesticides in agricultural runoff. In addition, natural developmental phases of a continuously inundated marsh include senescence of the emergent aquatic vegetation that is not able to regenerate by seed and the subsequent development of open water, like what happened in Weaver Bottoms. If all stresses and the natural ecology of the potential restoration site are considered, a combination of treatments may be more effective than concentrating on one factor. In the case of Weaver Bottoms, effective restoration may require active intervention such as water level manipulation to encourage revegetation or planting of desired species. It is likely, however, that carp must be controlled until the vegetation is fully established. Moreover, additional structures may be required, as was outlined for Phase II of the project, to reduce further fetch and wave energy.

In addition to thorough identification and treatment of causes of degradation, the degree of degradation of the site must be considered. Weaver Bottoms had lost most of the emergent vegetation before construction of the rehabilitation project. Regardless of the causes, it is more difficult to restore habitat quality of a severely degraded site than a less degraded site. When natural processes of the functioning ecosystem are lost, it is very difficult to reestablish the complex interrelationships of factors that support those processes. Although it is not advisable to rush into an extensive restoration project without thoroughly investigating the causes of degradation, it is equally unadvisable to begin restoration efforts when the site has lost the capability to recover. Restoration measures will be much less extensive and costly if restoration efforts are applied as early as possible after degradation of the site has been identified and is most easily reversed.

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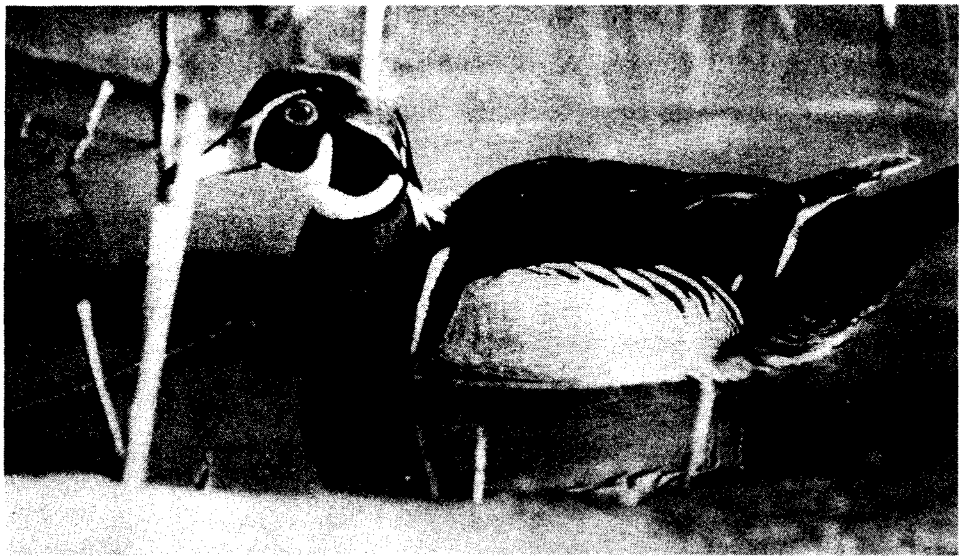
Guidelines for Placement and Management of Wood Duck Nest Boxes in Wetland Habitats



PURPOSE: This technical note provides recommendations for the location and management of nest boxes to supplement natural nest sites in a variety of wetland habitats for wood duck (*Aix sponsa*). The wood duck is associated with forested wetlands throughout much of the United States and is a common resident at Corps of Engineers reservoir projects.

BACKGROUND: Since wood ducks are cavity nesters, they are closely associated with wetland habitats where there is an abundance of snag trees and natural cavities. However, birds will readily accept specially made boxes constructed of wood, metal, or plastic in areas where the lack of suitable nest sites is responsible for limiting increases in breeding wood duck populations. Such settings include reservoir backwater areas, tributary streams, tailwater areas, subimpoundments, abandoned sand or gravel pits, oxbow lakes, and beaver ponds.

Nest box programs have been established throughout the United States with approximately 5 percent of the juvenile component of the fall flight population of wood ducks attributable to production in boxes. Nest box programs have yielded a set of general criteria that will increase the chances of success for a nest box project. These fall into three general categories: (1) nest box placement, (2) predator management, and (3) monitoring and maintenance.

PLACEMENT: Ideal nesting and brood-rearing habitat for wood ducks consists of shallowly flooded areas with an interspersion of flooded trees and shrubs, emergent and floating vegetation, and open water areas. Before implementing a wood duck nest box program, a survey should be conducted to determine the adequacy of natural cavities and to assess brood-rearing habitat. If the current nesting population is high, the efficacy of a nest box program should be questioned. Areas smaller than 4.0 ha are usually considered marginal as brood-rearing habitat if they are separated by more than 46 m of land. However, complexes of beaver ponds and/or small streamside areas are acceptable if the individual units are interconnected by water corridors.

- Height. Nest box height is still debated among researchers and managers. Several studies have shown that nest sites >9 m above ground are more acceptable to wood ducks than are lower sites. However, a recent study in Alabama showed that when wood ducks were given a choice of three boxes at different heights on the same tree, they selected the lowest (2.0 m above ground) 54 percent of the time. Boxes located at heights of 3.8 m and 5.6 m were used at rates of 24 and 22 percent, respectively. The lowest boxes also had higher nest success (60 percent) than the higher boxes (50 percent and 45 percent) in this study. Boxes will generally need to be located higher in areas subject to flooding. Experimentation with box placement to determine the optimum heights to attach boxes may be necessary.

  Wood ducks prefer boxes located over water and duckling survival increases the less distance they must travel over land to reach brood-rearing sites. Boxes placed over water are also less subject to predation. If it is not feasible to place boxes over water, they should be located as close to potential brood-rearing habitat as possible.

- Orientation. The orientation of the boxes' cavity opening appears to have an effect on wood duck use. Ducks prefer cavities with entrances directed toward the nearest forest opening in both upland and bottomland habitats. Cavities that are readily visible from the path of nest-searching females (in flight or swimming) are apparently used at a higher rate. Placement of boxes with the entrance oriented away from nearby roads should also be considered. This would serve to reduce noise disturbance to the nesting female as well as minimize potential vandalism.

  Boxes should be installed out of direct sunlight, since studies have shown that high temperatures can destroy eggs and result in nestling mortality. This is critical if plastic or metal boxes are being used, especially in the southern United States. Cypress boxes are found to be significantly cooler than plastic boxes exposed to the same conditions.

- Density. As the breeding density of wood ducks increases, box occupancy, clutch size, and the occurrence of dump nesting increases. Dump nesting (also referred to as nest parasitism) is the condition where a nest site receives eggs from many females (hatching success in these nests is usually zero); the incidence of dump nesting is greatest where there are high population densities.

  Dense breeding populations coupled with high box visibility and closely spaced boxes will lead to high rates of nest parasitism. When boxes are installed, they should be placed singly in visually isolated sites, which would reduce the opportunity for females to observe other wood ducks at active sites. Although this strategy might reduce occupancy rates, it should reduce nest parasitism, increase nesting success, and encourage high productivity.

PREDATOR MANAGEMENT: Wood duck nest losses from artificial boxes are generally higher than for natural cavities because predators will quickly learn to associate boxes with an easy meal. Commonly reported predators of wood duck nests and hens include the great horned owl (*Bubo virginianus*), raccoon (*Procyon lotor*), bobcat (*Lynx rufus*), squirrels (*Sciurus* spp.), red-bellied woodpecker (*Melanerpes carolinus*), European starling (*Sturnus vulgaris*) and snakes. Raccoons especially have been reported to seek out boxes and will frequently enter every box on a management area during a single feeding period. Some predators reportedly develop a "search pattern" directed toward locating boxes. A nest box program should not be implemented without ensuring that predator guards and/or other protective devices are used to prevent the boxes from becoming death traps. Snakes can be especially significant predators on wood ducks, and most snakes found inside boxes have been reported to consume the entire clutch. Rat snakes (*Elaphe* spp.) are usually implicated as having the greatest impact on wood duck nestlings. It is very difficult to exclude snakes from boxes because those that are at least 1.7 m in length can bypass most predator guards or can drop into boxes from overhanging limbs. The application of a sticky material on structures supporting duck boxes has been used to reduce snake predation. This approach may not be cost effective in large nest box programs.

Several types of predator guards can protect boxes. These include aluminum bands, metal cones, and similar devices. Special entrance hole designs have been used to exclude raccoons. Predation can also be discouraged by installing boxes on poles over water or by mounting them on bent metal brackets that extend approximately 0.6 m from a tree or post.

BOX MONITORING AND MAINTENANCE: Maintenance and monitoring of nest boxes is essential to a successful program. Depending on the size of the nest box program, complete checks or a random sampling of boxes can help in estimating the number of breeding pairs in an area. If possible, this information should be supplemented with data from harvest records maintained by state agencies and the U.S. Fish and Wildlife Service.

When developing a wood duck nest box survey program, basic information on each nest box installed at the project should be collected into a file. A standardized fact sheet should be prepared for each box; this sheet should contain at least the information shown in Figure 1.

Areas with nest boxes should be given a site number within a compartment, or other defined location, and a number should be inscribed on each box to facilitate record keeping. Managers can identify and move boxes from unproductive sites and maintain those that are successful. The numbering system will also facilitate handling of data. Ideally, boxes should be numbered sequentially as they are installed. It is recommended that fact sheets be filed according to site within each compartment.

At a minimum, wood duck nest boxes should be inspected twice a year. A maintenance check of all boxes should be made each winter, usually no later than mid-January, beginning with a pre-nesting check of all boxes to replace or repair those that are damaged. Additionally, old nesting material and egg shells should be removed, and boxes should be treated with a disinfectant to reduce ectoparasite problems. Wood shavings or sawdust should be added to a depth of 10 to 16 cm to provide a proper nesting substrate. Timing of pre-nesting box maintenance must precede the normal nest initiation dates.

Box use should be assessed soon after the ducklings have left the nest. During this inspection, data should be collected on wood duck use, including number of eggs and number of eggs hatched, and use by other species. Boxes not used and box failures should also be noted. If possible, the reason for box failure (e.g., abandonment, predation, flooding, human disturbance) should be indicated. These data should be compiled for each site on the inspection sheet (Fig. 2). It may be possible to inspect only a sample of boxes at each site during the summer survey period due to time and personnel constraints.

An annual summary report of wood duck nest box use should be filed with the District. The following information should be displayed for each site: habitat type; total number of boxes at the site; the survey sample size; and the number and percentage of boxes not used, boxes failed, wood duck use, other use, and total use.

NEST BOX FACT SHEET

Compartment # ______________ Site # ______________ Box # ______________

Location ____
(include map for each site showing precise location of boxes)

Habitat Code ______________ Site Description ______________

____

Box Type (wood, plastic, metal, etc.) ______________

Type of Support ____
(tree, wooden pole, metal pole, etc.)

Height of Base Above Water ______________

Predator Guard (Y/N) ______ Type of Guard ______________

Box Exposure ____
(shaded, partly shaded, full sun)

Direction of Hole Entrance - N NE E SE S SW W NW

Date Installed ____/____/____ Installed by ______________

Annual Inspection Record:

Date	Box Condition and Comments
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________
____/____/____	______________

Figure 1. Fact Sheet

WOOD DUCK NEST BOX INSPECTION SHEET

PROJECT______________________ RECORDER__________________________ DATE____________

COMPARTMENT #________________ SITE_____________________ LOCATION__________________

Box #	Box Type	Habitat Code	Wood Duck Use			Other Species Use			Not Used	Box Fail	Box Condition & Comments
			Y/N	#Eggs	#Hatched	Y/N	Species	#Eggs			

Figure 2. Inspection Sheet

CONCLUSIONS: Wood duck nest boxes are a useful management tool in areas that contain good brood-rearing habitat but are deficient in natural nest sites. Although a wood duck nest box program can increase local production, the proper preservation and management of bottomland hardwoods and associated wetland habitats are most critical to the well-being of wood duck populations. Management for natural cavities should be encouraged as much as possible.

ADDITIONAL RECOMMENDED READING:

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